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Abstract

Phantom-based training of real-time instrument tracking and navigation for neurosurgical applications

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Accurate intraoperative navigation of neurosurgical instrumentation, e.g., ultrasound aspirators, is important for safe tumor resection, preservation of eloquent structures, and enhanced patient safety [1]. To mimic clinical routines in a safe, off-patient training scenario, we developed and demonstrated a marker-based navigation workflow using an anthropomorphic brain phantom with an embedded tumor.

The phantom, modeled in Blender, was mounted in a custom 3D-printed enclosure fitted with three rigidly affixed reference markers, establishing a fixed spatial relationship between the tumor and the fiducials. All printed components - the enclosure and a custom instrument marker mount derived from the STL geometry of a Söring GmbH (Quickborn, Germany) aspirator - were fabricated on a Stratasys F370 fused deposition modeling (FDM) 3D printer (Stratasys Ltd., Eden Prairie, MN, USA) using acrylonitrile butadiene styrene (ABS) filament.

Using a Polaris Vega XT (NDI, Waterloo, Ontario, Canada) optical tracker and pivot calibration, we determined the precise position of the aspirator tip relative to its marker set and transformed it into the phantom coordinate system. The models were loaded and visualized in 3D Slicer [2], and real-time tracking of the phantom and instrument was achieved via OpenIGTLink [3] and the PLUS Toolkit [4], enabling continuous visualization of the tool tip with respect to the tumor. This integrated navigation setup and phantom provide a cost-effective, reproducible platform for training and simulation of stereotactic neurosurgical procedures.

Author's statement

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